Improving the Precision of Irrigation Using High-Resolution Thermal Imagery

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Permanent crops require watering to ensure survival

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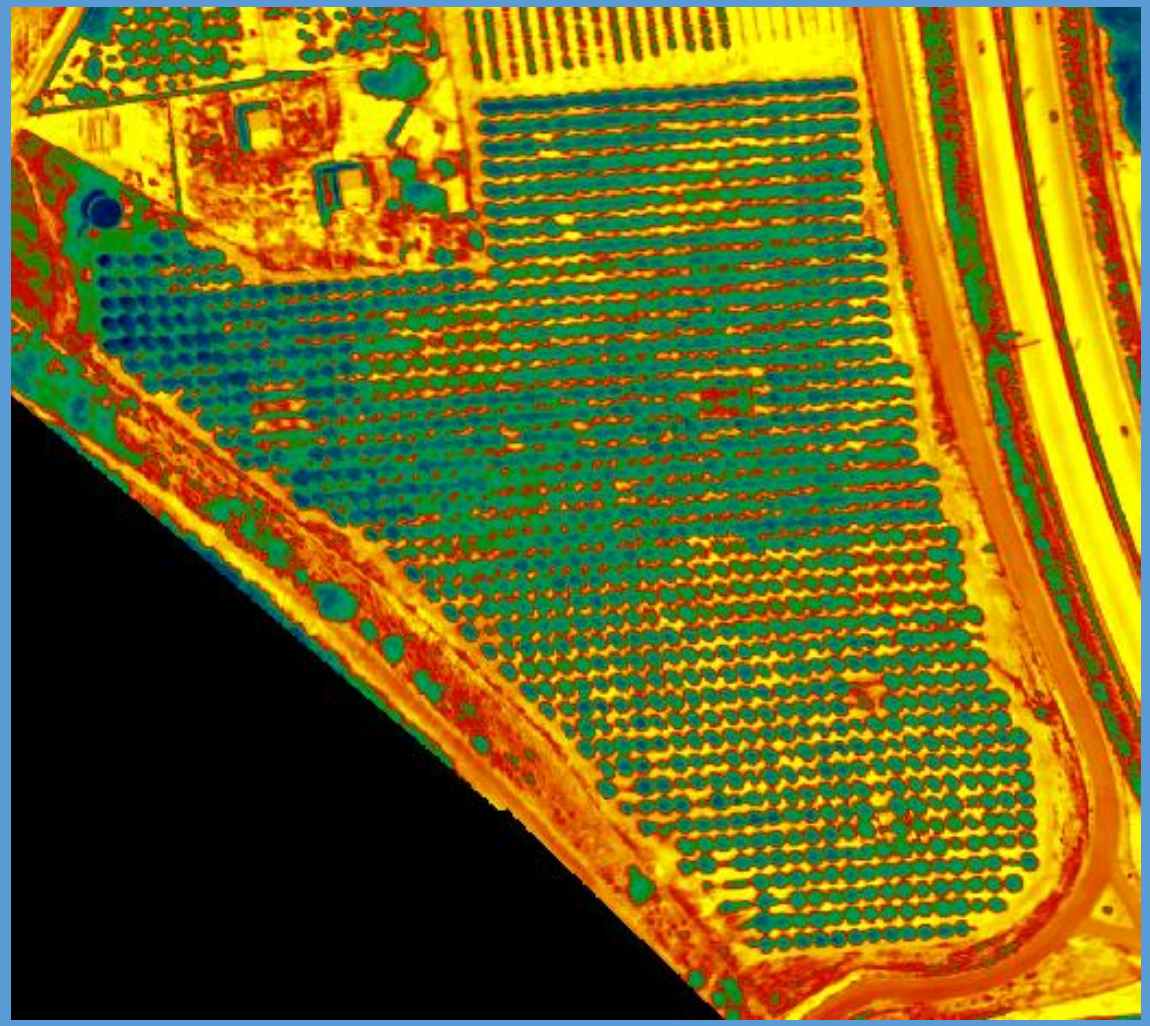
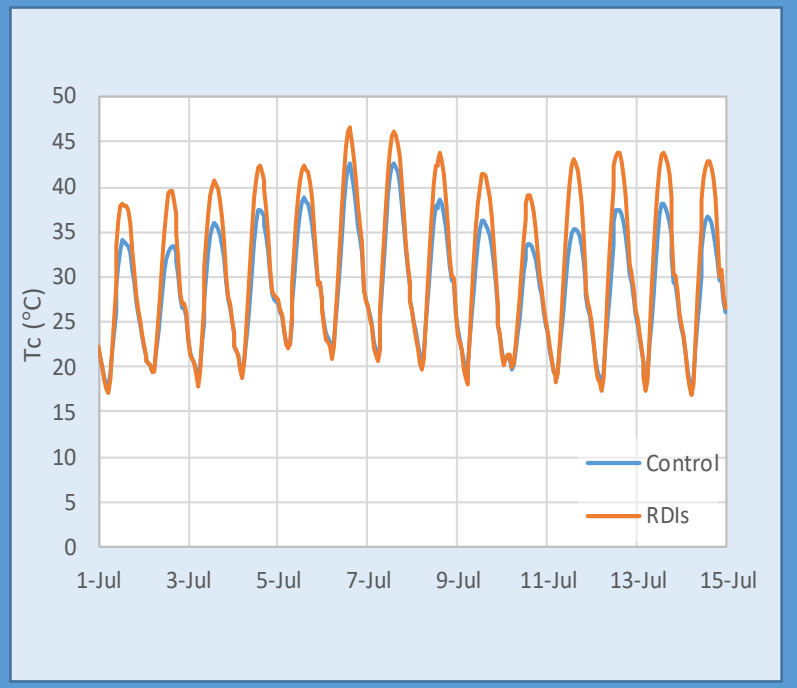
Permanent crops require watering to ensure survival

Objective: To develop tools to optimize water use in irrigated orchards

Proximal and remote sensing of canopy temperature

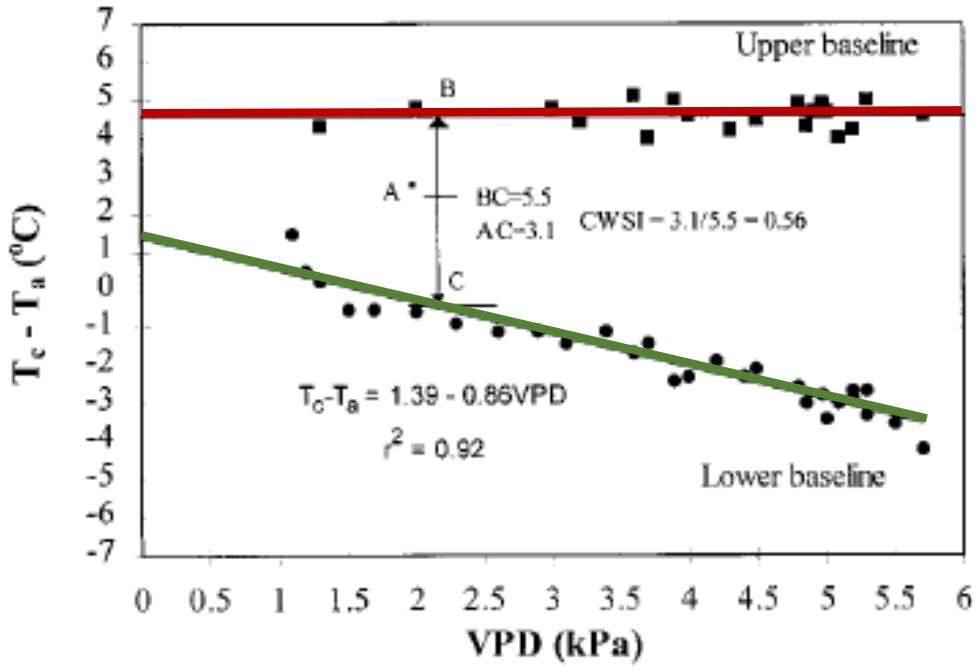




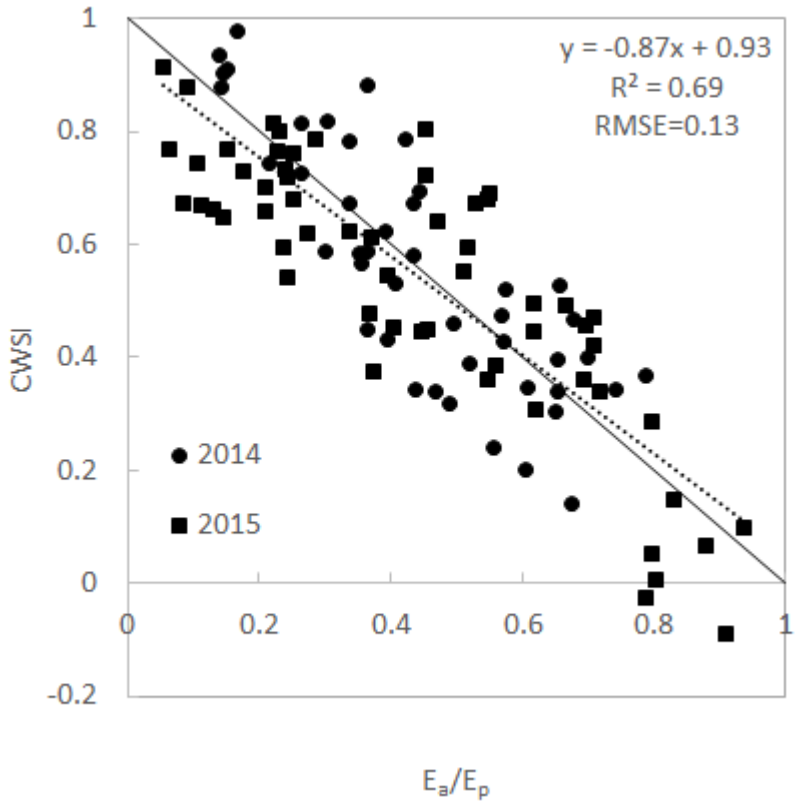
Normalization by evaporative demand

Crop Water Stress Index

$$CWSI = \frac{(Tc\text{-}Ta) - (Tc\text{-}Ta)_{LL}}{(Tc\text{-}Ta)_{UL} - (Tc\text{-}Ta)_{LL}} = 1 - \frac{E_a}{E_p}$$

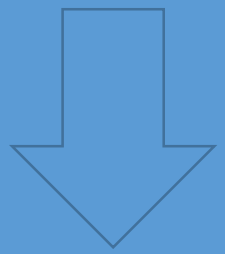


Irmak et al. 2000 (*Agronomy Journal*)



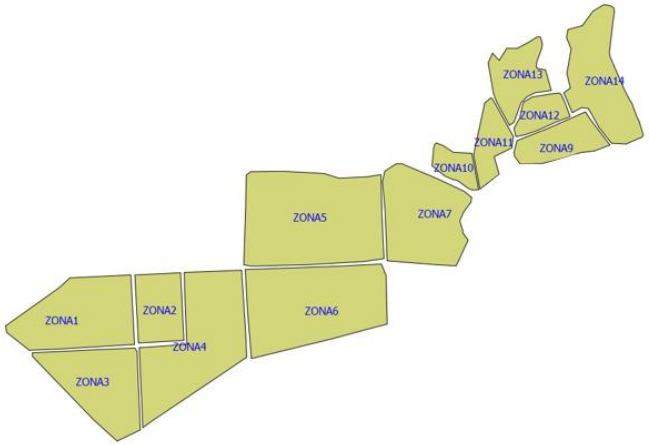
- ✓ Analysis of the spatial variability of water status within management units
- ✓ Relationship with yield

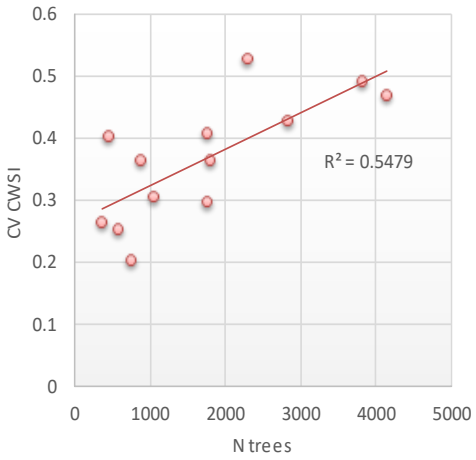
Increased size of management units

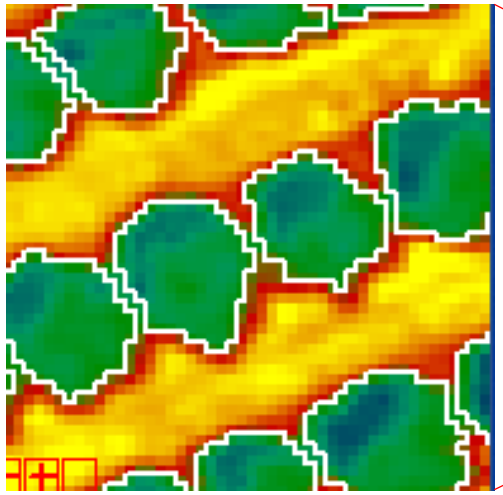


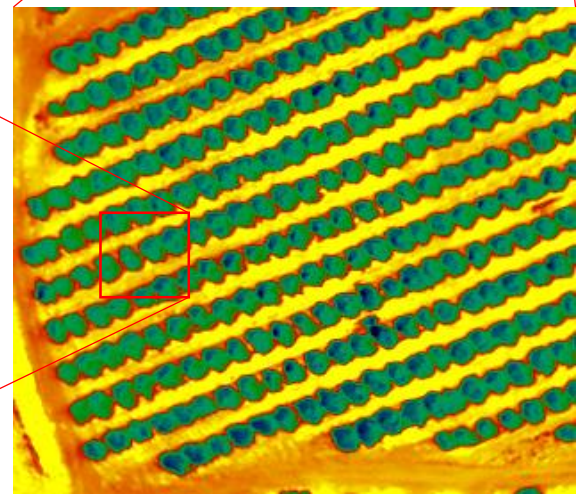
Increased spatial heterogeneity of management units

ANALYSIS OF THE FREQUENCY DISTRIBUTION OF CWSI VALUES WITHIN THE IRRIGATION UNITS









Zone ID	1	2	3	4	5	6	7	8	9	10	11	12	13
N trees	2306	1047	1759	2825	4139	3832	1794	751	368	579	446	881	1758
Mean	0.19	0.31	0.27	0.32	0.32	0.22	0.38	0.54	0.45	0.42	0.35	0.36	0.50
SD	0.103	0.094	0.109	0.136	0.153	0.110	0.138	0.109	0.119	0.107	0.143	0.133	0.149
CV	0.527	0.307	0.408	0.427	0.470	0.492	0.364	0.202	0.263	0.252	0.403	0.363	0.297

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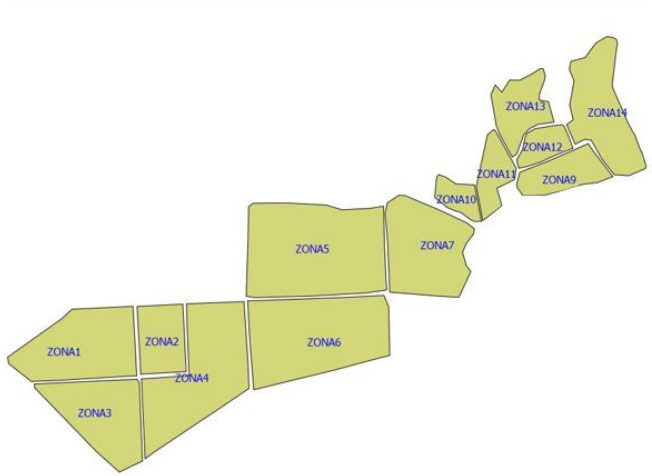
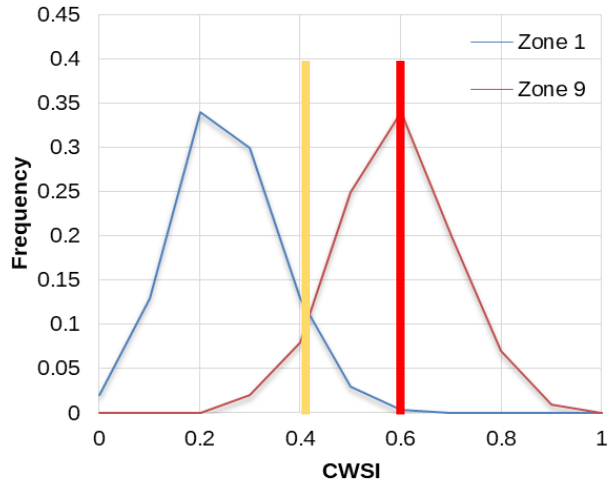
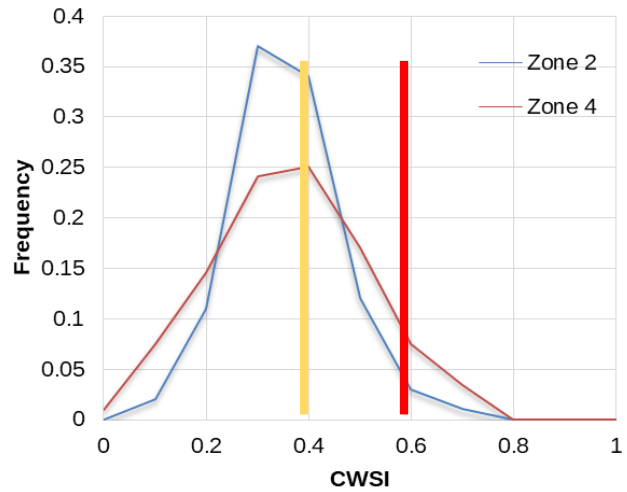
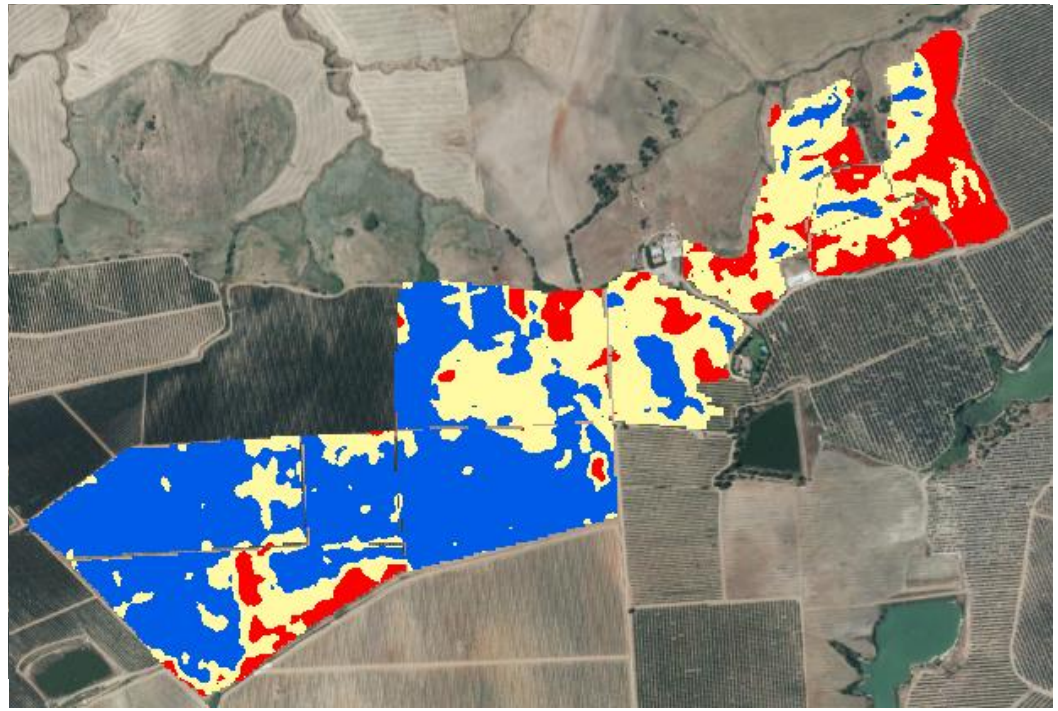
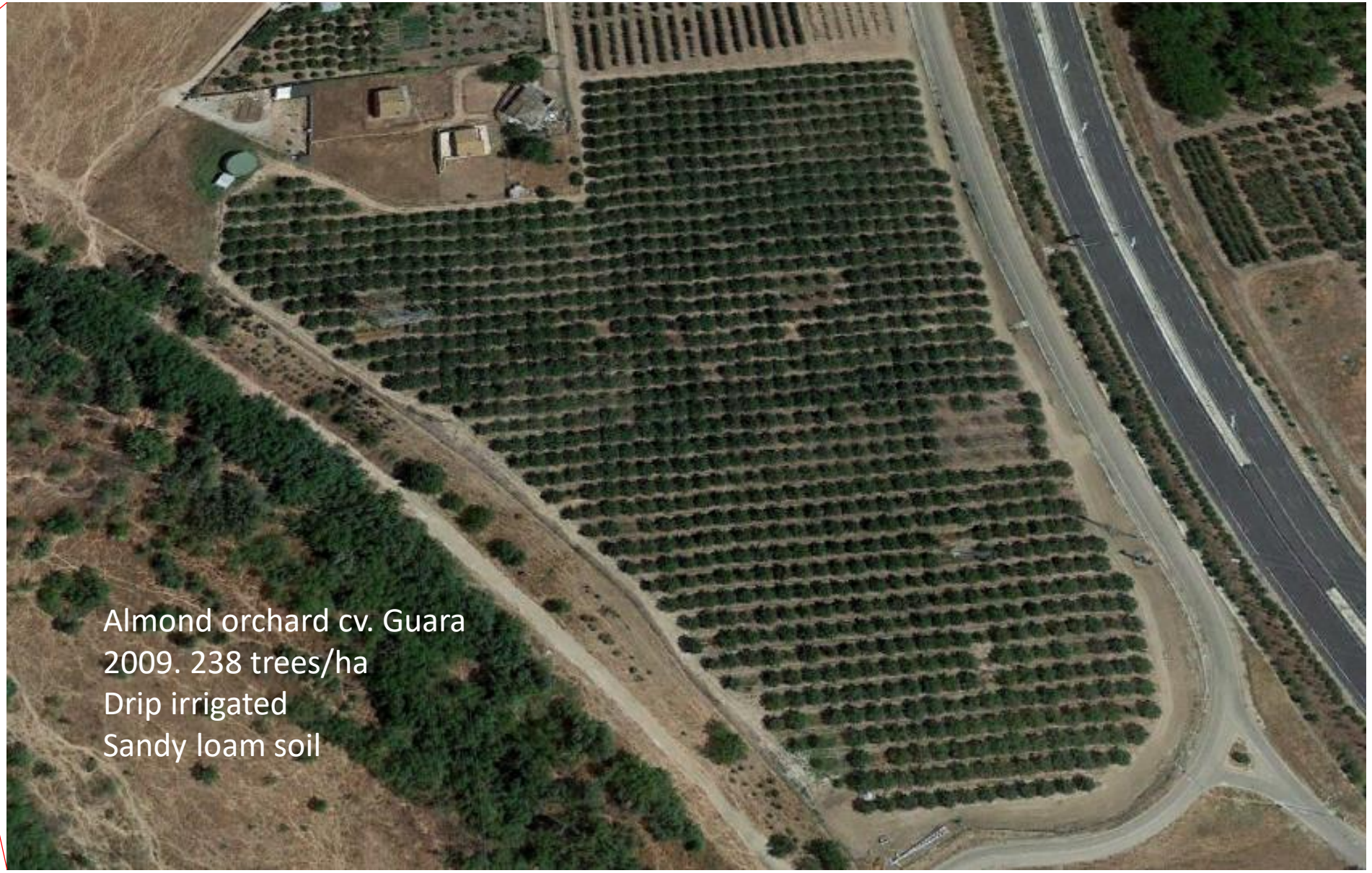








✓Relationship with yield



Experimental design and irrigation treatments

- Control: 100% water requirements
- RDIs: 15% of Control during kernel-filling stage
- Three more treatments (moderate water stress)

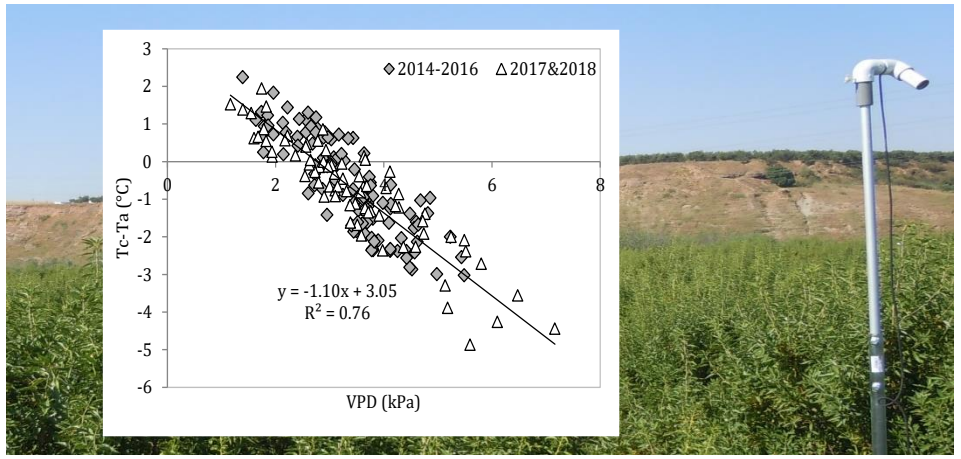
4 replicates/treatment (replicate: 4 x 4 trees)

Measurements

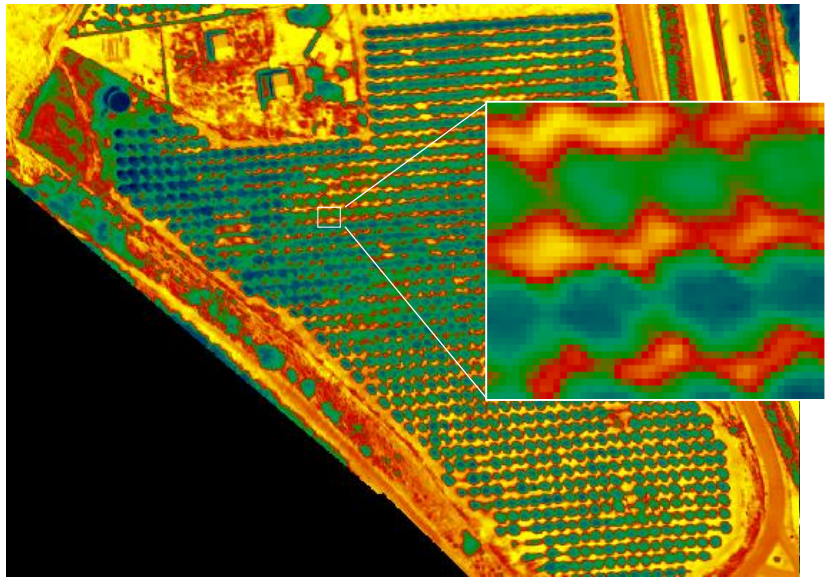
Water potential, stomatal conductance

Sap flow sensors, installed on one tree per treatment (two probes per tree)

Canopy temperature, measured continuously over two trees per treatment

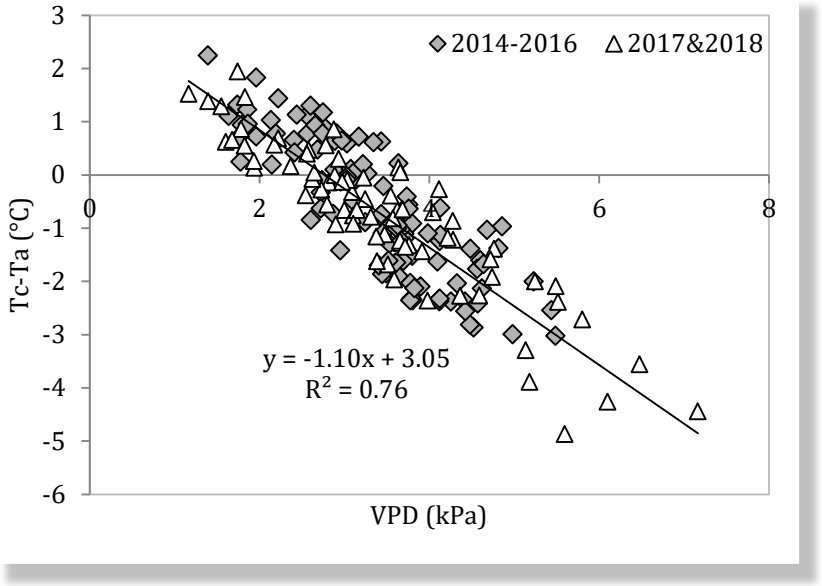


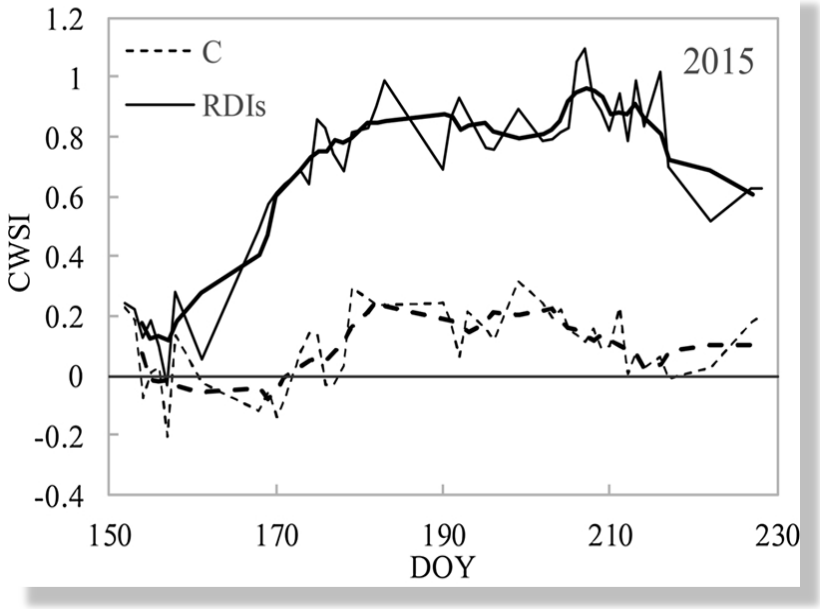
Airborne campaigns



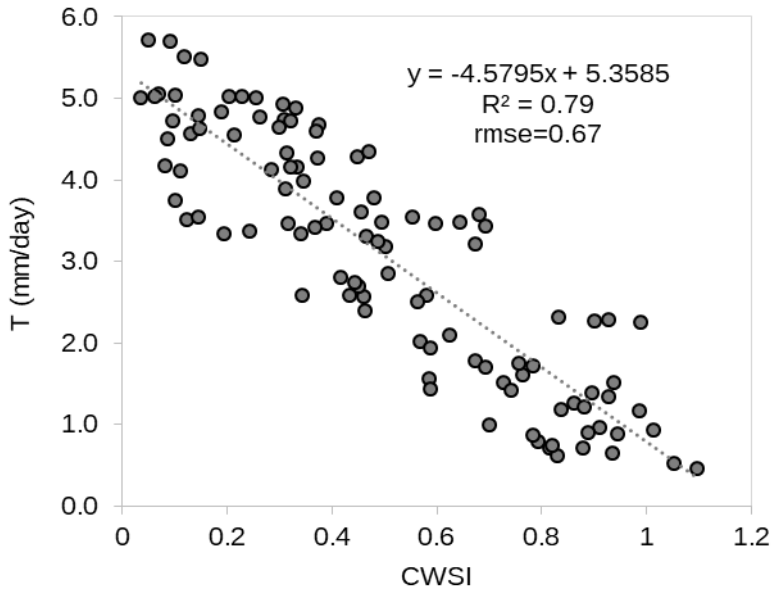
Yield at harvest

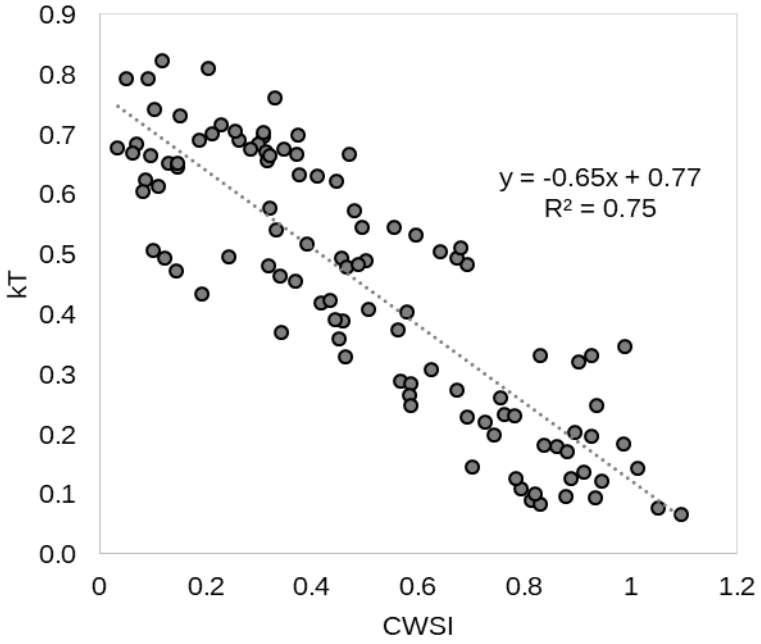
Results from IRT sensors: definition of the NWSB and CWSI evolution



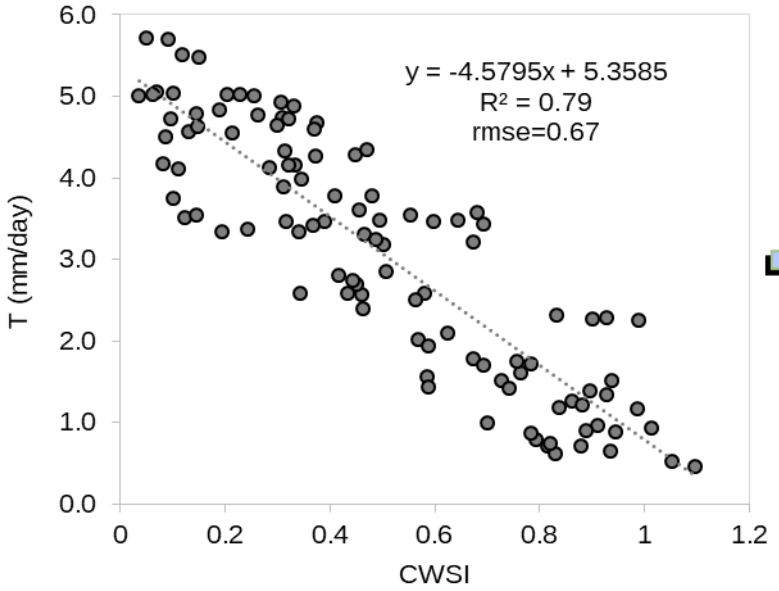


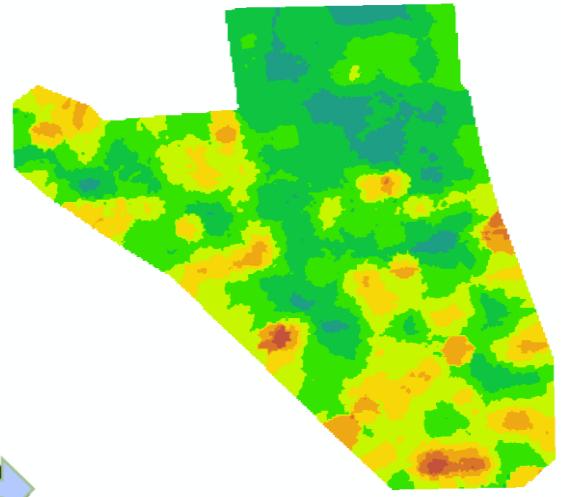
Sap flow measurements and relationship with canopy temperature



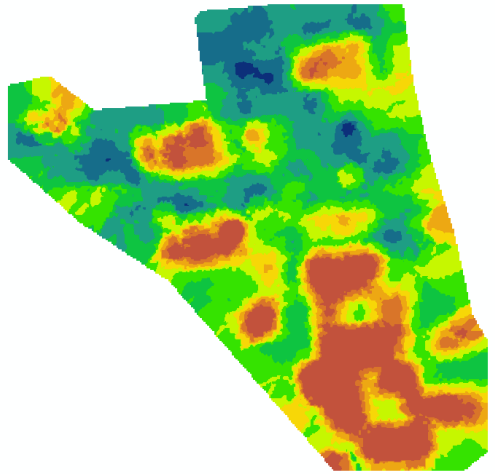


Airborne imagery: maps of transpiration. Delineation of homogeneous areas





DOY 152 2017



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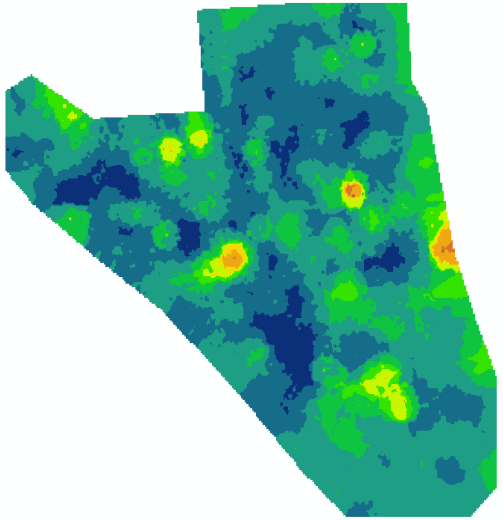

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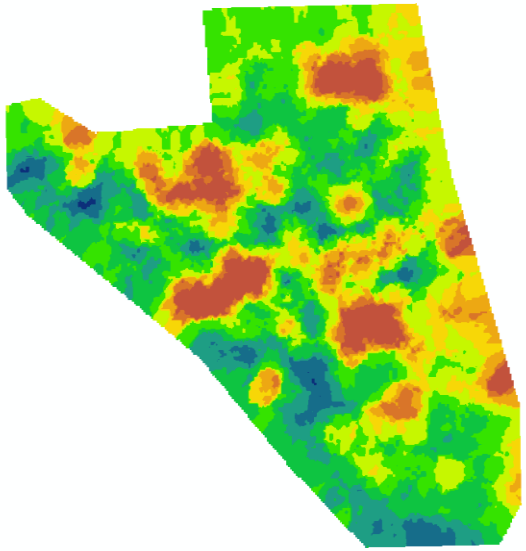
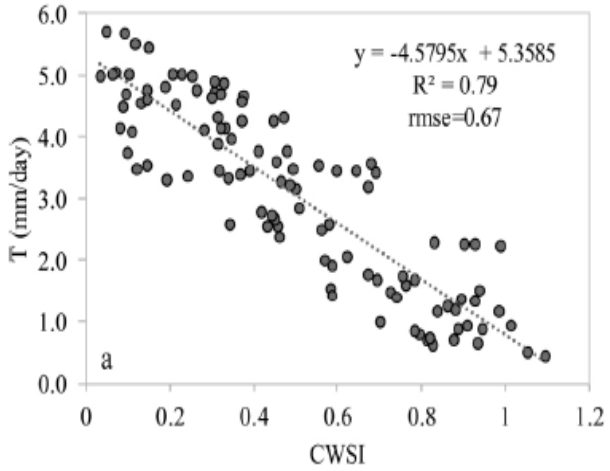


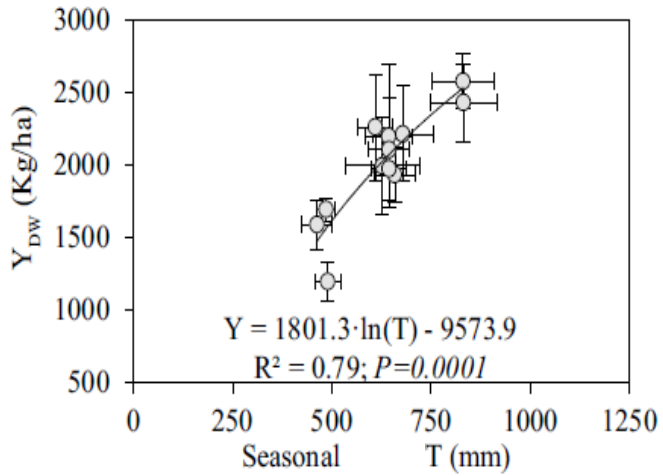
DOY 207 2018

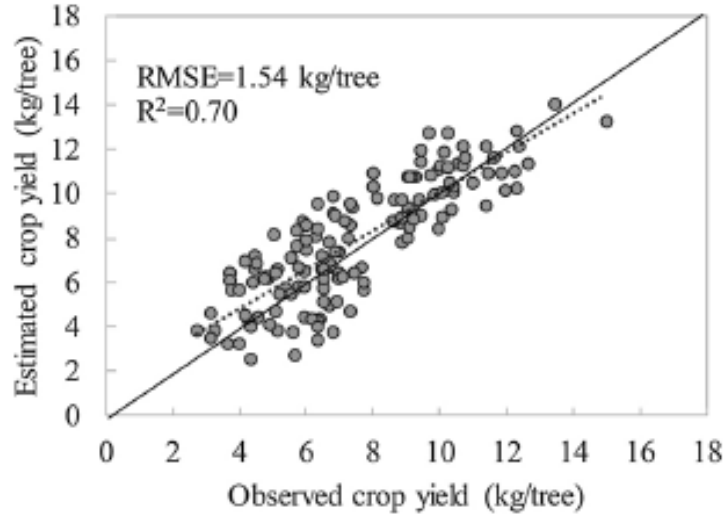
T (mm)

- 5.4-4.9
- 4.9-4.4
- 4.4-4.0
- 4.0-3.5
- 3.5-3.1
- 3.1-2.6
- 2.6-2.2
- 2.2-1.7
- 1.7-1.2
- 1.2-0.8

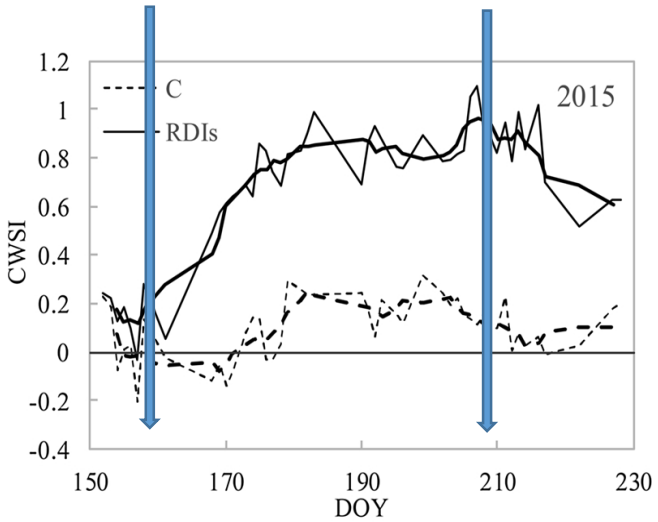
From Lopez-Lopez et al., 2018



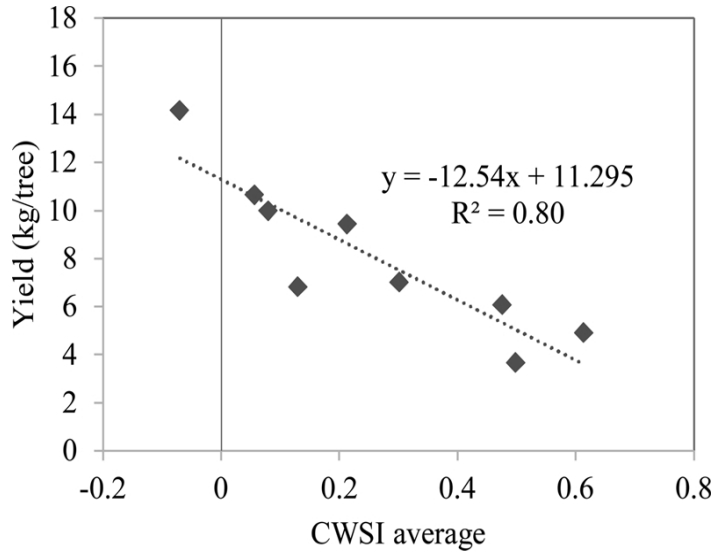


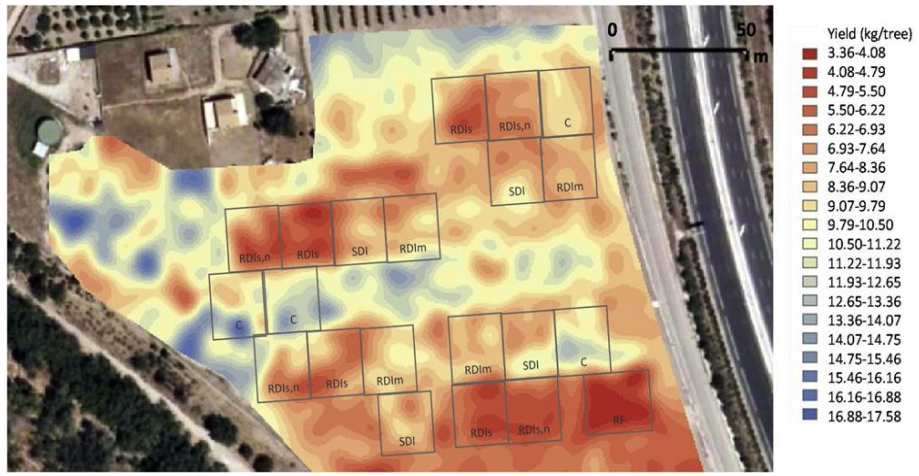


Thermal imagery



From Gonzalez-Dugo et al., 2019





Conclusions

- ✓ The CWSI is closely related to the crop water status. This relation was used to identify the spatial variability of water status and derive maps of transpiration.
- ✓ By combining high-frequency thermal data (IRT sensors), high-resolution thermal imagery (UAVs, aircrafts) and agronomical knowledge, it was possible to derive the relationship between CWSI and yield under specific growing conditions.

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Thanks for your attention!!

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